US005888108A

United States Patent [19]

Iriono

[11] **Patent Number: 5,888,108**

[45] **Date of Patent: Mar. 30, 1999**

[54] **PROPULSION SYSTEM FOR MARINE DRIVE**

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[73] Assignee: **Sanshin Kogyo Kabushiki Kaisha**, Japan

[21] Appl. No.: **828,599**

[22] Filed: **Mar. 31, 1997**

[30] **Foreign Application Priority Data**

Mar. 29, 1996 [JP] Japan 8-076733

[51] **Int. Cl.**[6] **B63H 1/15**

[52] **U.S. Cl.** .... **440/52**; 440/80; 416/134 R

[58] **Field of Search** .... 416/93 A, 134 R; 440/52, 80, 81

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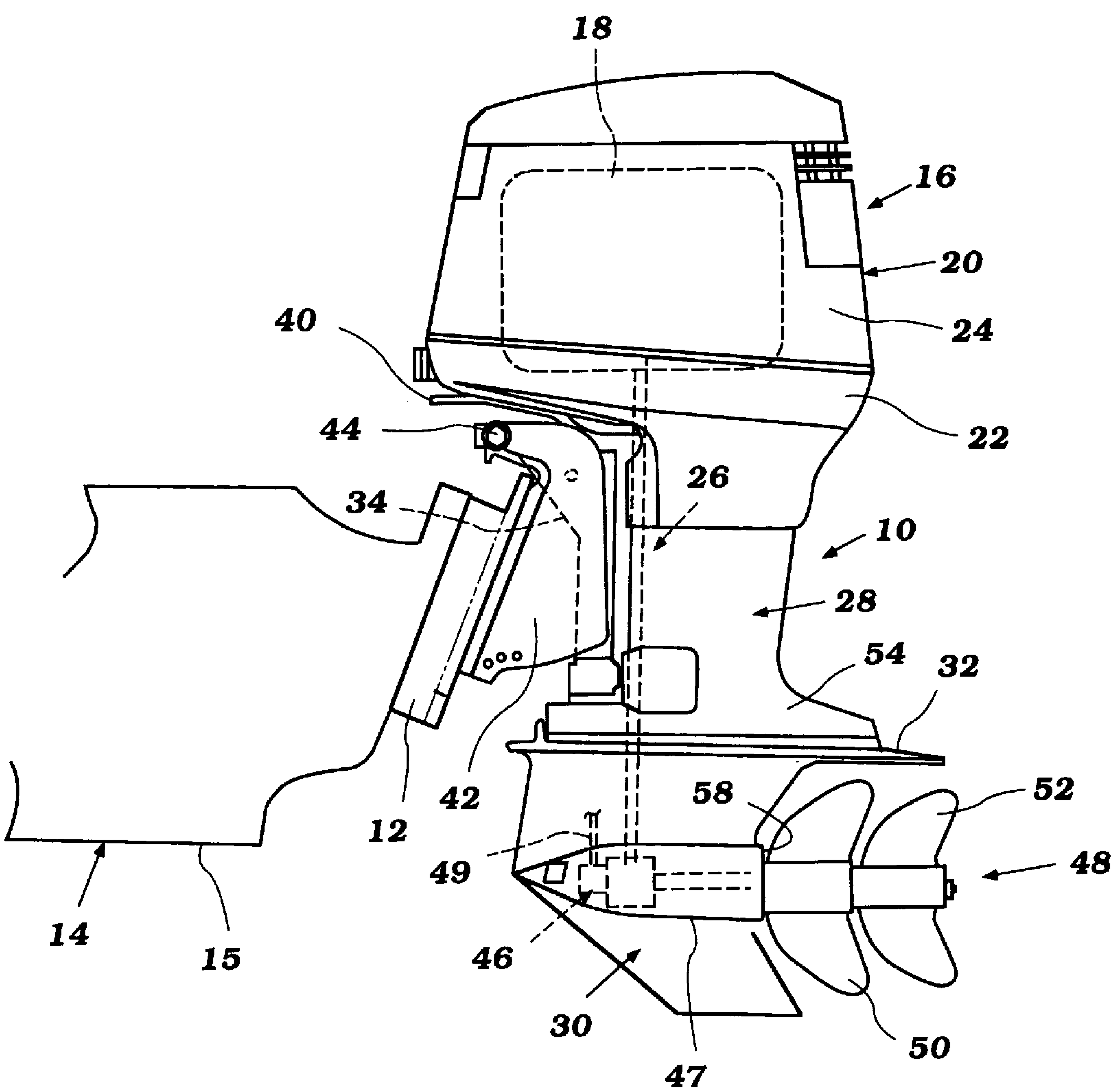
Primary Examiner—Stephen Avila
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, LLP

[57] **ABSTRACT**

A propulsion system includes an improved propeller design which increases the durability of the propeller for enhanced rotational vibration damping, while simplifying the structure of the propeller. A rubber coupling is placed within a space that is secured between a propeller hub and an inner member of the propeller. The rubber coupling resiliently couples the propeller hub to the inner member with only the inner member and the propeller hub maintaining the space in which the rubber coupling is placed. The substantially constant size of the space generally isolates the rubber coupling from cyclic tension and compression stresses in the axiel and radial directions as the propeller rotates to improve the durability of the rubber coupling.

26 Claims, 9 Drawing Sheets



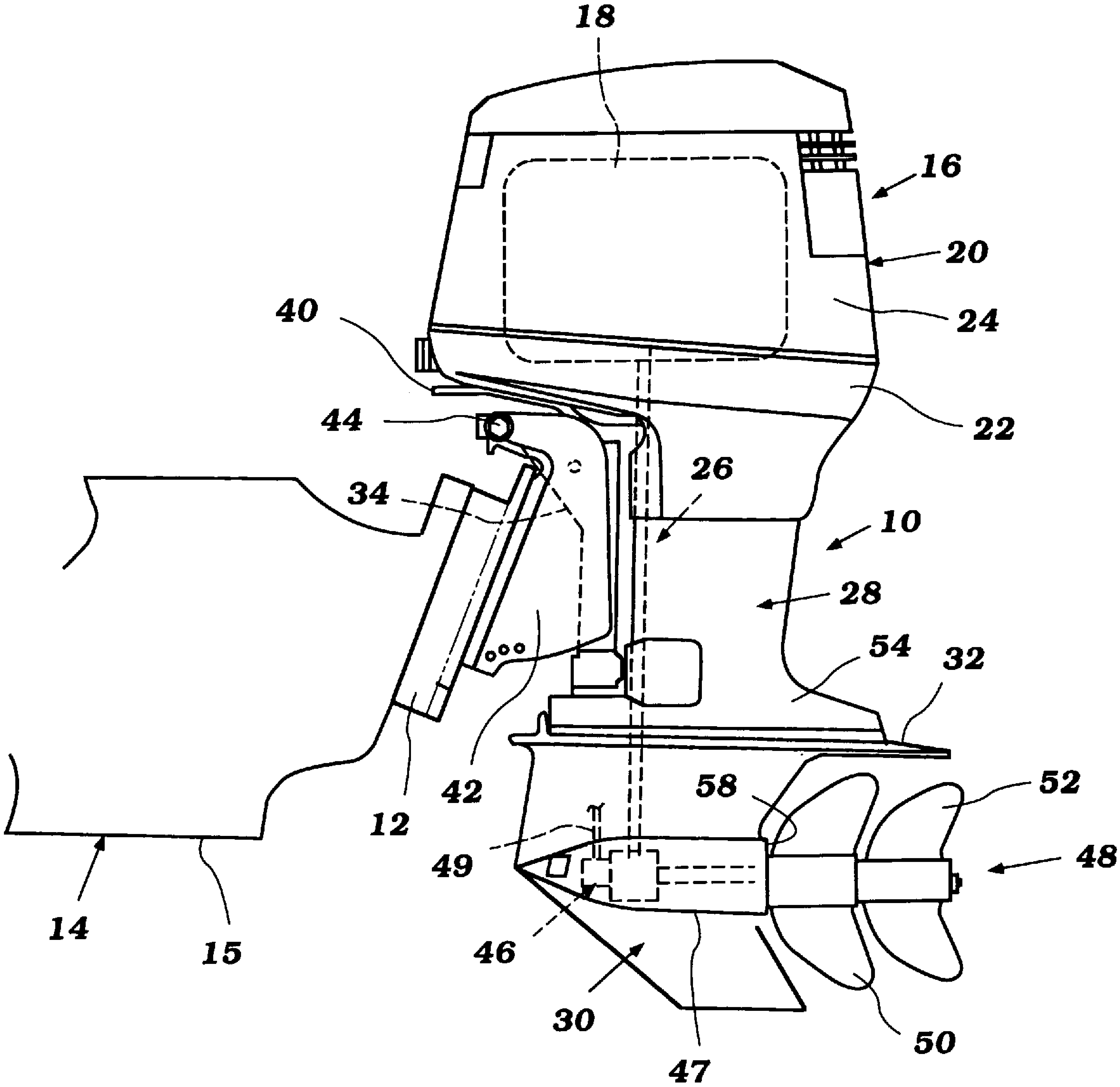

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Figure 1

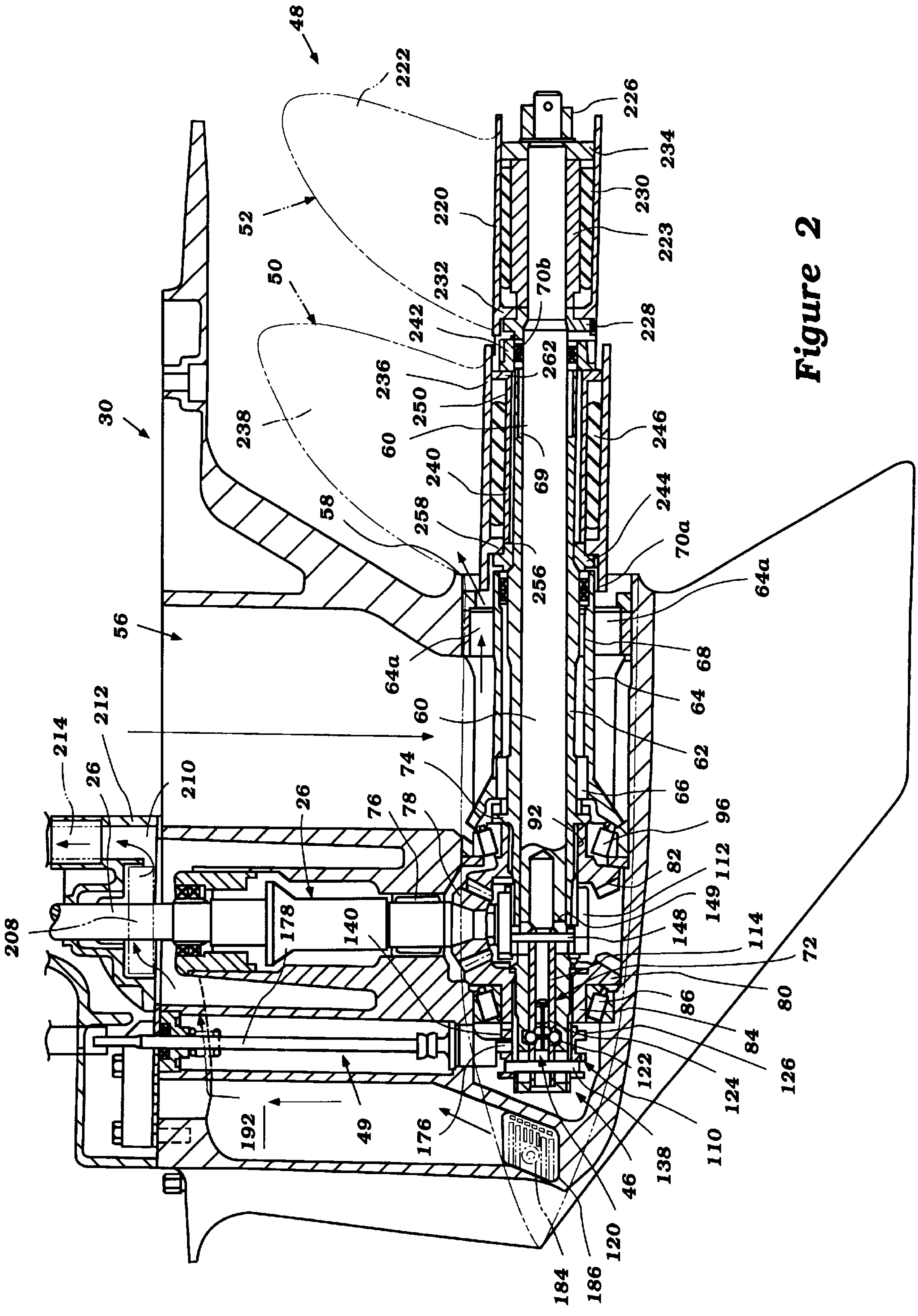
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Figure 2

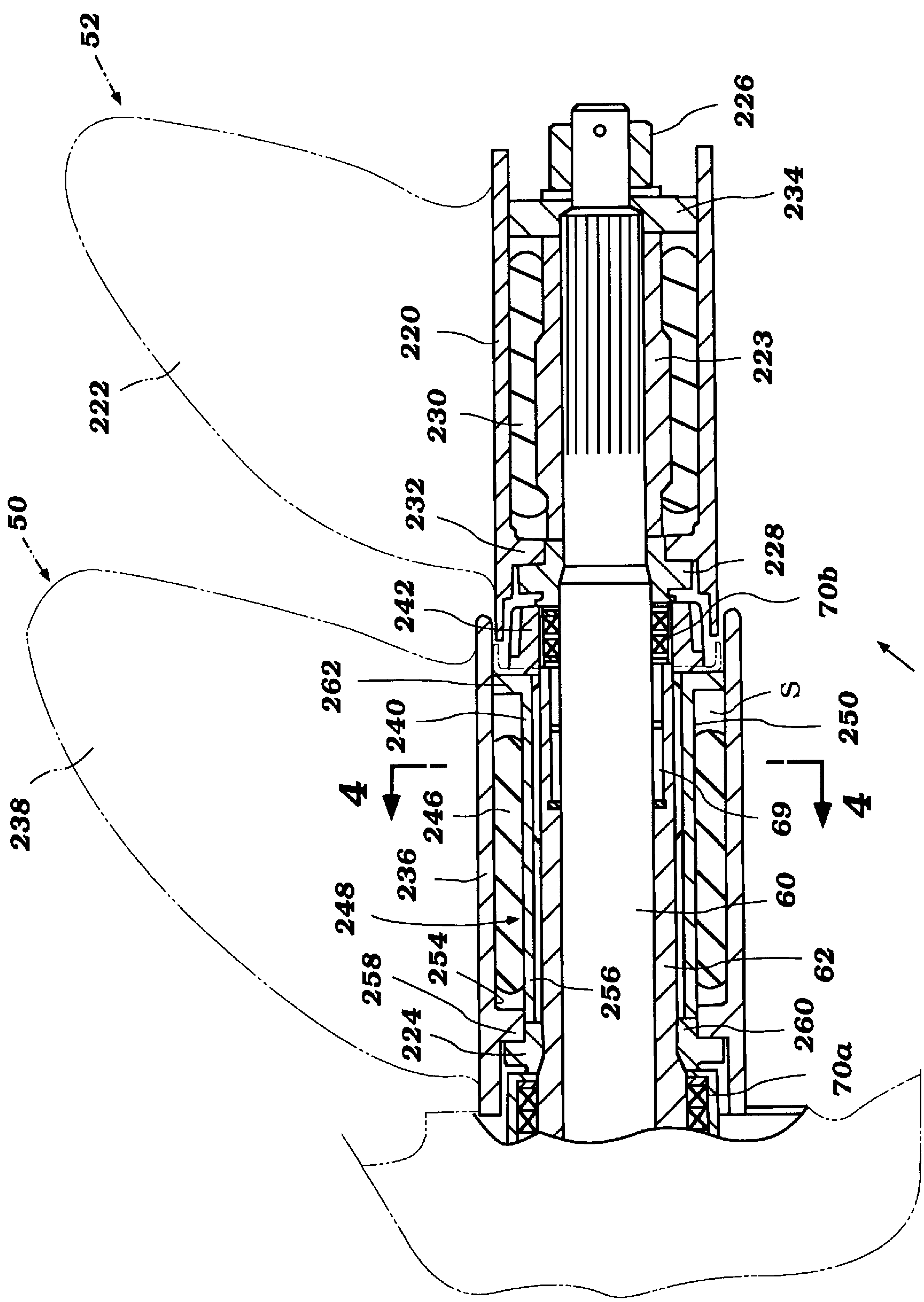
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Figure 3

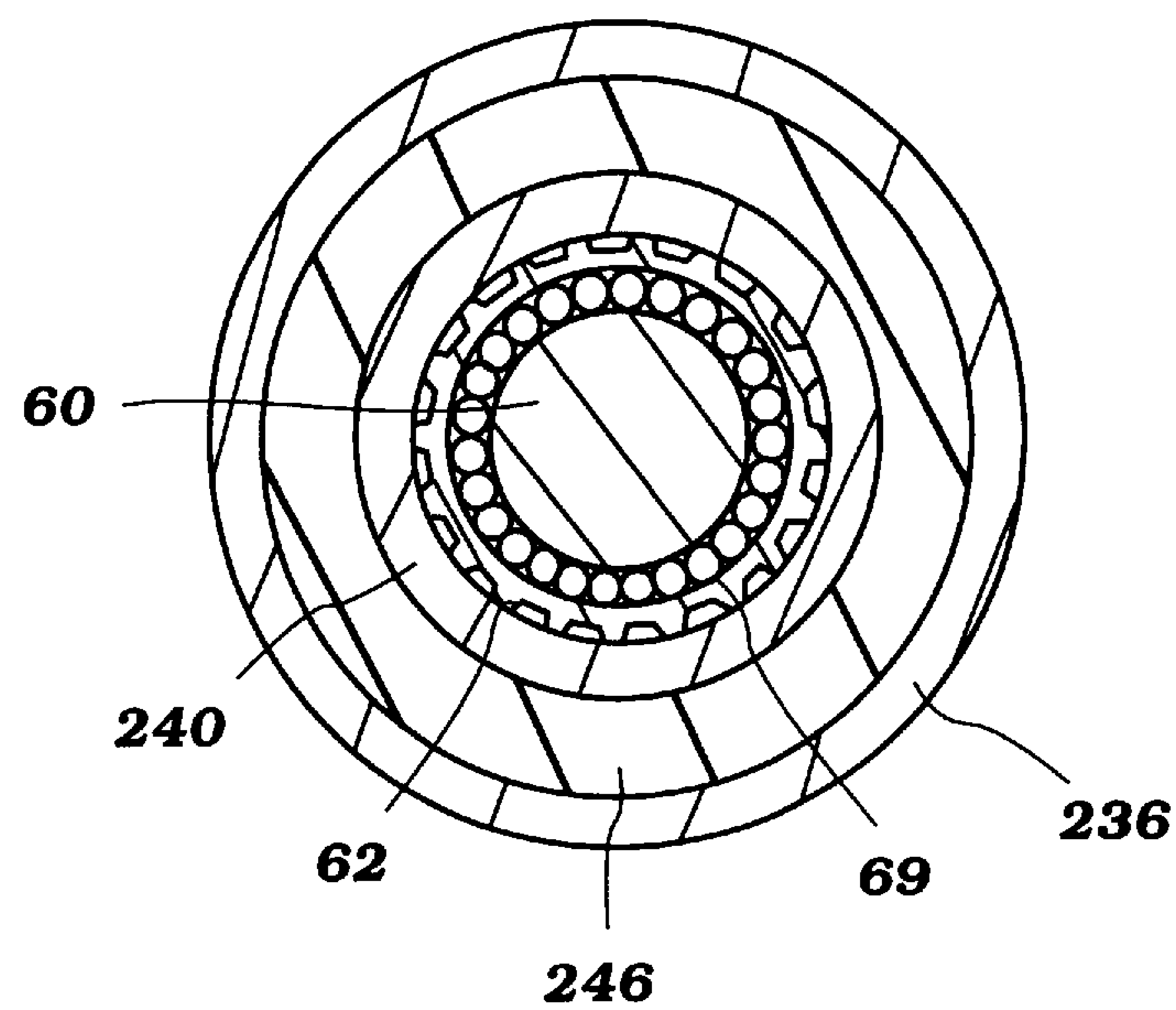

Figure 4

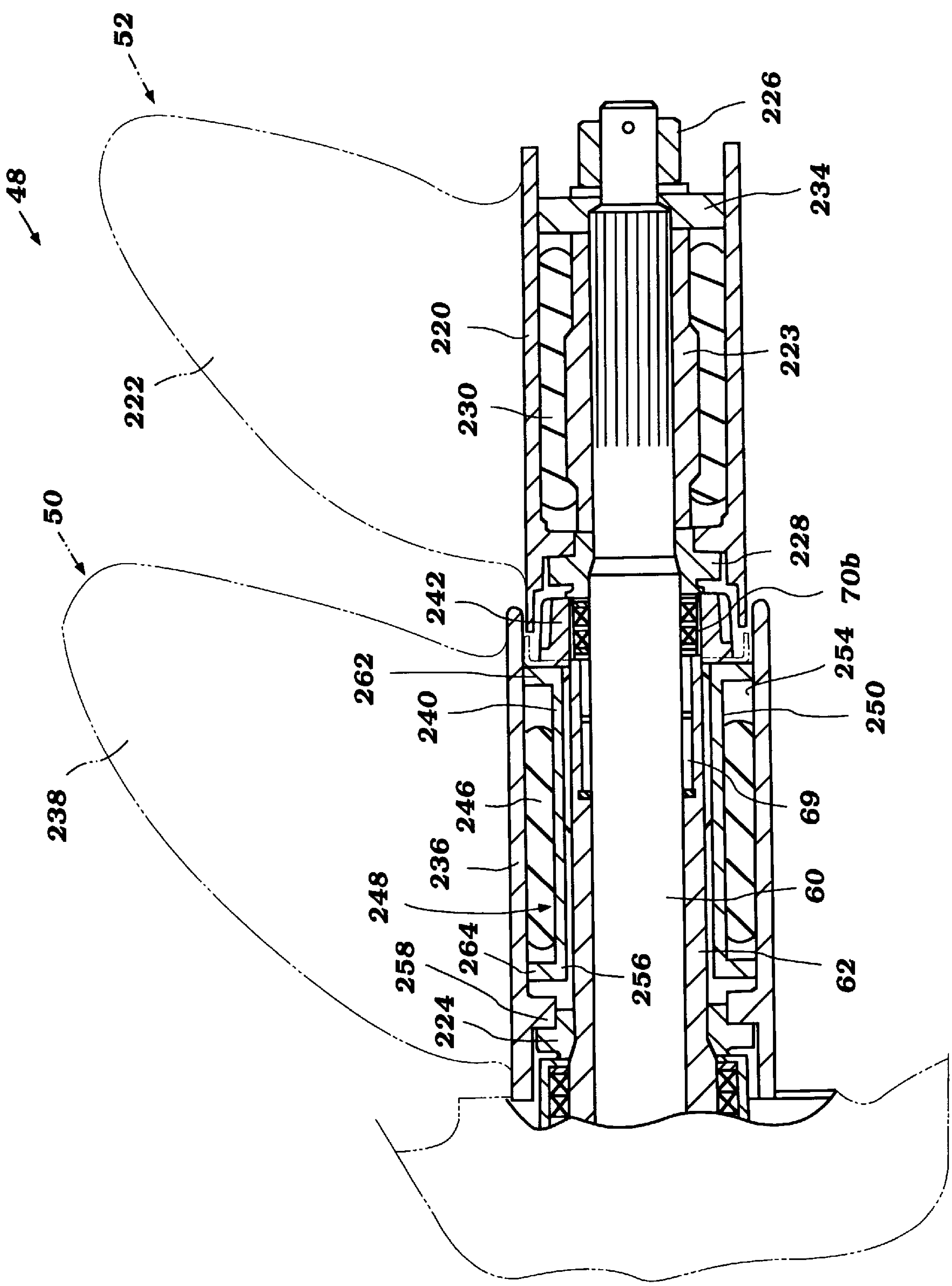
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Figure 5

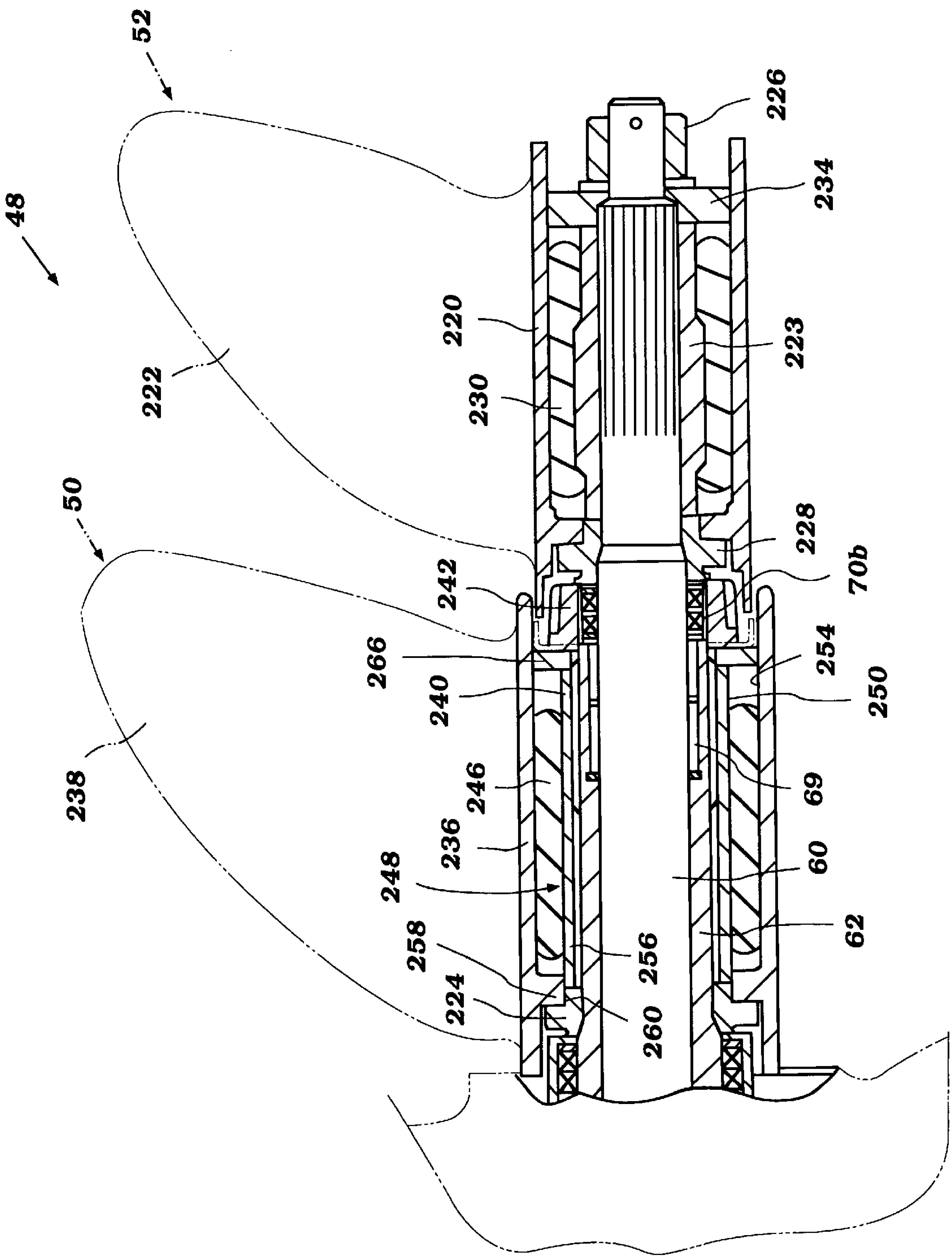
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Figure 6

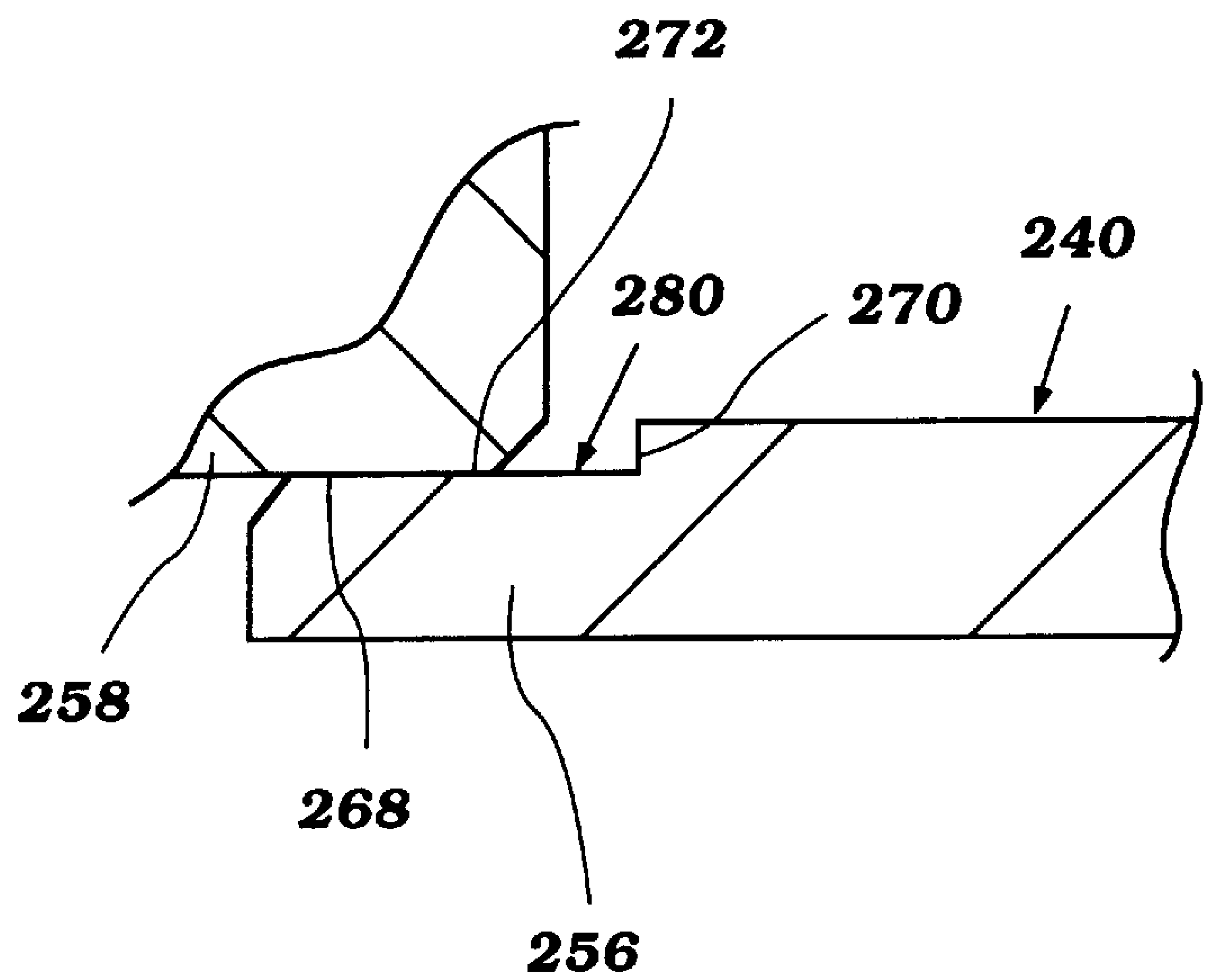

Figure 7

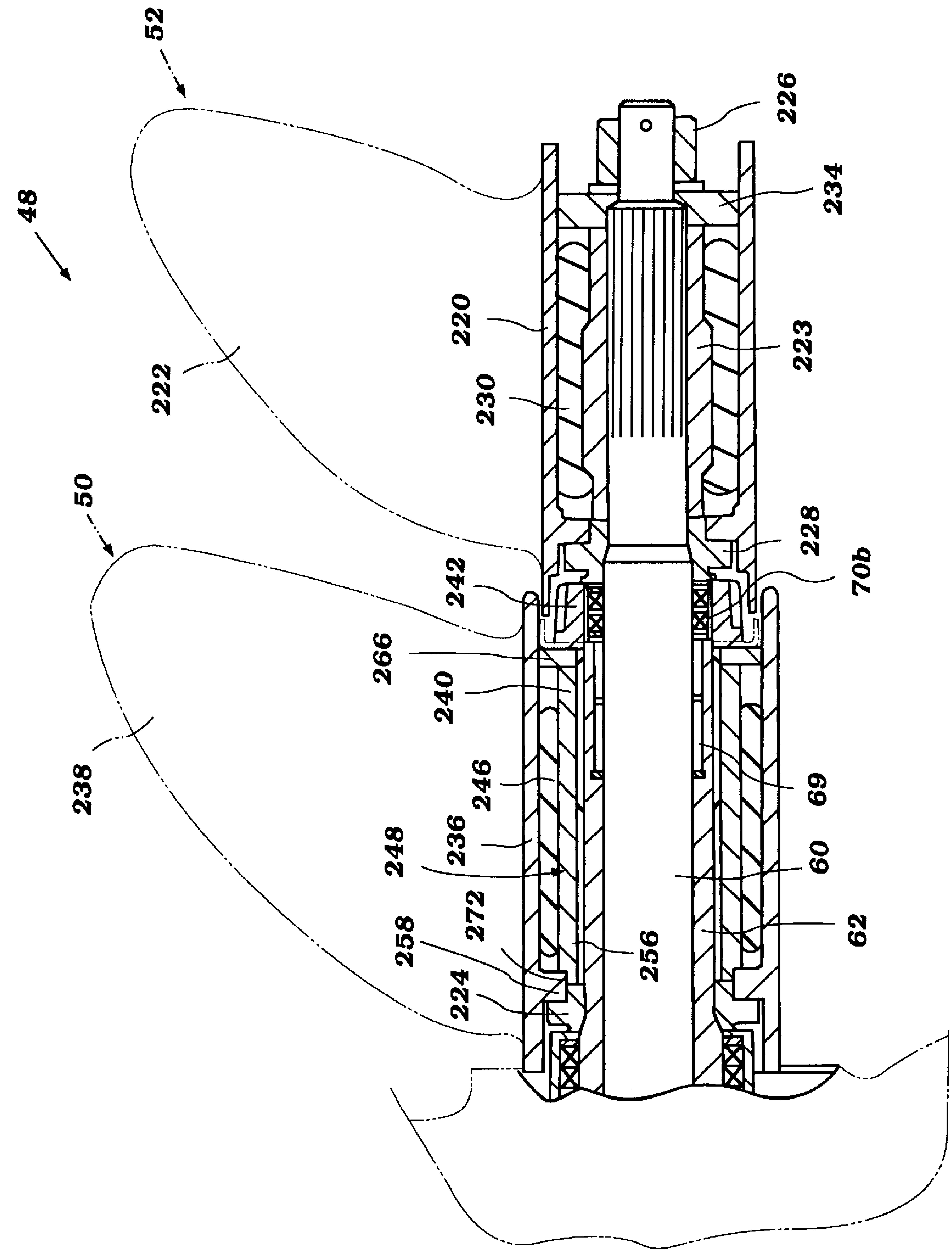
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Figure 8

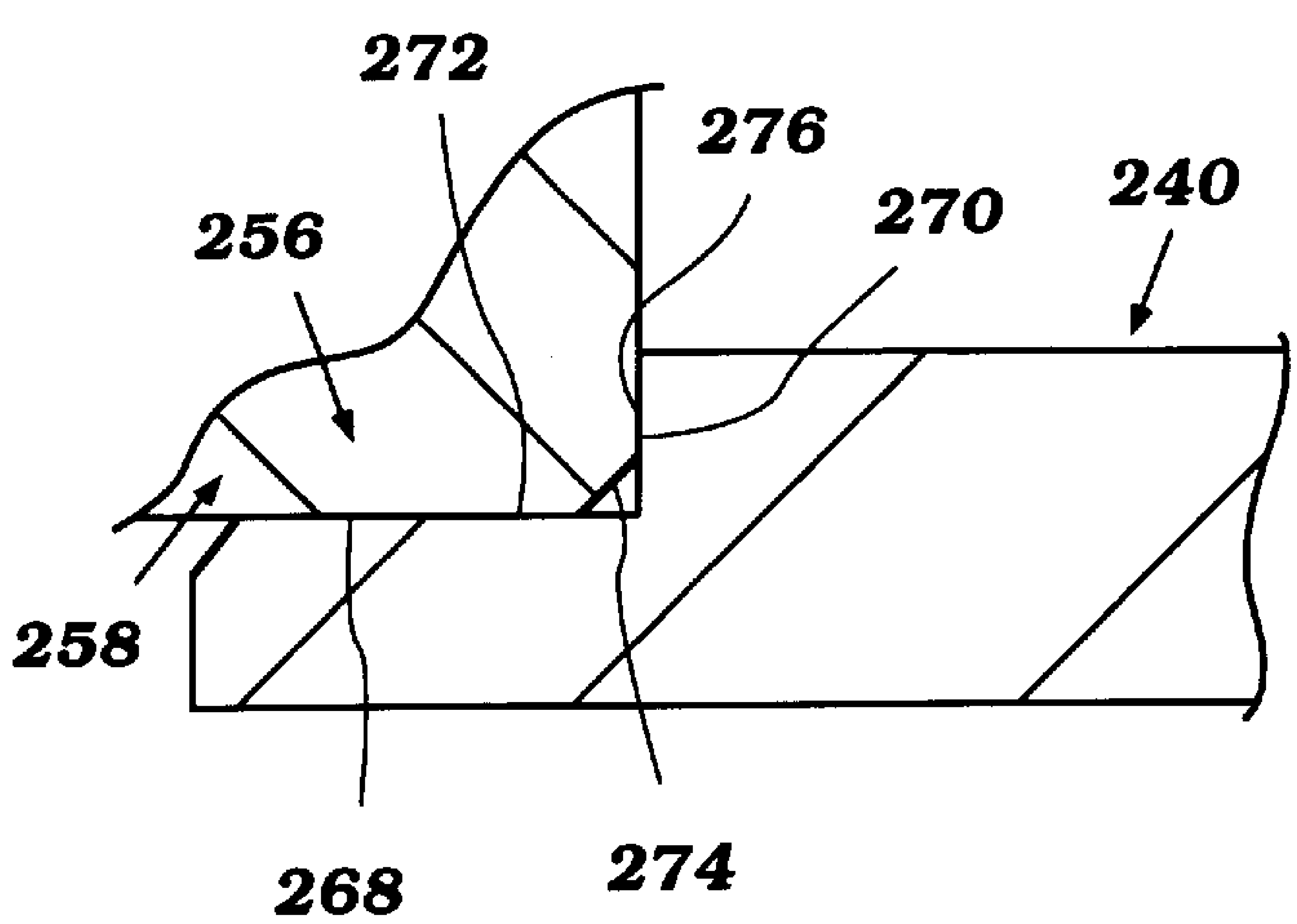

Figure 9

PROPULSION SYSTEM FOR MARINE DRIVE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a marine drive, and in particular to a propulsion system for a marine drive.

2. Description of the Related Art

Many watercraft employ outboard motors that are mounted on the aft end of the watercraft. An outboard motor generally includes a power head that houses an engine, a drive shaft housing situated below the power head, and a lower unit that is positioned below the drive shaft housing. The lower unit typically houses a transmission and a propulsion shaft that drives a propulsion device.

Some outboard motors employ counter-rotating propeller systems which utilize a pair of counter-rotating propellers that operate in series about a common rotational axis. By using propeller blades having a pitch of opposite hand, the dual propeller arrangement provides significant improvement in propulsion efficiency.

Prior propellers used with counter-rotating propeller systems tend to suffer from a number of drawbacks, however. Prior designs tend to be overly complicated, being formed by a multitude of components. For instance, a propeller often includes a propeller hub positioned about an inner sleeve that attaches to a propeller shaft. A rubber coupling couples the propeller hub to the inner shaft. At least one spacer is usually used to support the hub about the propeller shaft beyond a rear end of the inner sleeve. The use of all of these individual components complicates the assembly of the propeller and adds to labor and material costs.

Some conventional propeller design also use the rubber coupling to support at least a portion of the propeller hub about the inner sleeve. In this use, at least a portion of the rubber coupling undergoes cyclic tension and compression loads. The rubber eventually fatigues under these stresses and collapses into itself. The collapsed rubber coupling consequently looses a certain degree of its elasticity and no longer effectively absorbs rotational vibrations within the propeller.

SUMMARY OF THE INVENTION

A need therefore exists for a simply-structured propeller design with a reduced number of components that improves durability while enhancing vibration damping between the propeller and the propeller shaft.

One aspect of the present invention thus involves a propeller adapted to be coupled in driving relation with a propeller shaft of a marine drive. The propeller comprises a propeller hub that supports at least one propeller blade. An inner member is adapted to be affixed against rotation relative to the propeller shaft and is arranged within the propeller such that a space is defined solely by the inner member and the propeller hub. This space occurs between opposing portions of the inner member and the propeller hub. A resilient coupler cooperates with the inner member portion and with the opposing propeller hub portion to resiliently couple together the propeller hub and the inner member. The coupler is disposed within the defined space between the inner member and the propeller hub. This structure of the propeller coupling reduces the number of components to simplify assembly and reduce material and labor costs.

Another aspect of the present invention involves a propulsion system for a marine drive that includes a front propeller and a rear propeller which are arranged in series and rotate about a common axis. A pair of concentric propeller shafts drive the propellers. A first propeller shaft of the pair drives the front propeller and a second propeller shaft of the pair drives the rear propeller. At least one of the front and rear propellers comprises a propeller hub that supports at least one propeller blade. An inner member of the propeller is adapted to be affixed against rotation relative to the respective propeller shaft and is arranged within the propeller such that a space is defined solely by the inner member and the propeller hub. This space occurs between opposing portions of the inner member and propeller hub, and is generally constant. A resilient coupler cooperates with the inner member portion and with the opposing propeller hub portion to resiliently couple together the propeller hub and the inner member. The coupler is disposed within the defined space between the inner member and the propeller hub. As a result of the constant size of the space in which the resilient coupler is placed, the coupler is generally isolated for cyclic tension and compression stresses as the propeller rotates, and consequently, the durability of the coupler is enhanced.

Further aspects, features, and advantages of the present invention will become apparent from the detailed description of the preferred embodiments which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features of the invention will now be described with reference to the drawings of preferred embodiments of the present marine propulsion system. The illustrated embodiments of the marine propulsion system are intended to illustrate, but not to limit the invention. The drawings contain the following figures:

FIG. **1** is a side elevational view of an outboard motor which incorporates a propeller system that is configured in accordance with a preferred embodiment of the present invention;

FIG. **2** is a sectional, side elevational view of a lower unit and the propeller system of the outboard motor of FIG. **1**;

FIG. **3** is an enlarged, sectional side view of the propeller system of FIG. **2**;

FIG. **4** is a cross-sectional view of the propeller system of FIG. **3** taken along line **4**—**4**;

FIG. **5** is a sectional side view of a propeller system configured in accordance with another preferred embodiment of the present invention;

FIG. **6** is a sectional side view of a propeller system configured in accordance with an additional preferred embodiment of the present invention;

FIG. **7** is an enlarged sectional view of a portion of a propeller of the propeller system of FIG. **6**;

FIG. **8** is a sectional side view of a propeller system configured in accordance with an additional preferred embodiment of the present invention; and

FIG. **9** is an enlarged sectional view of a portion of a propeller of the propeller system of FIG. **8**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

FIG. **1** illustrates a marine drive **10** configured in accordance with a preferred embodiment of the present invention. In the illustrated embodiment, the marine drive **10** is depicted as an outboard motor for mounting on a transom **12** of the watercraft **14** having a bottom surface **15**. It is contemplated, however, that those skilled in the art will readily appreciate that the present invention can be applied to stem drive units of inboard/outboard motors, and to other types of watercraft drive units, as well. Thus, as used herein, "marine drive" generically means an outboard motor, an inboard/outboard motor including a stem drive, and similar marine drive units. Additionally, "front" and "rear" are used herein in reference to the transom **12** of the watercraft **14**.

In the illustrated embodiment, the outboard motor **10** has a power head **16** which desirably includes an internal combustion engine **18**. The internal combustion engine **18** can have any number of cylinders and cylinder arrangements, and can operate on a variety of known combustion principles (e.g., on a two-stroke or a four-stroke principle).

A protective cowling assembly **20** surrounds the engine **18**. The cowling assembly **20** includes a lower tray **22** and a top cowling **24**. The tray **22** and the cowling **24** together define a compartment which houses the engine **18** with the lower tray **22** encircling a lower portion of the engine **18**.

The engine **18** is mounted conventionally with its output shaft (i.e., a crankshaft) rotating about a generally vertical axis. The crankshaft (not shown) drives a drive shaft **26**, as known in the art. The drive shaft **26** depends from the power head **16** of the outboard motor **10**.

A drive shaft housing **28** extends downward from the lower tray **20** and terminates in a lower unit **30**. The drive shaft **26** extends through the drive shaft housing **28** and is suitably journaled therein for rotation about the vertical axis.

A plate **32** extends outward in a substantially horizontal direction at the junction between the drive shaft housing **28** and the lower unit **30**. The plate **32** acts as a splash guard as well as a cavitation plate.

A conventional steering shaft assembly **34** is affixed to the drive shaft housing **28** by upper and lower brackets (not shown). The brackets support the steering shaft assembly **34** for steering movement. Steering movement occurs about a generally vertical steering axis which extends through a steering shaft (not illustrated) of the steering shaft assembly **34**. A steering arm **40**, which is connected to an upper end of the steering shaft, can extend in a forward direction for manual steering of the outboard motor **10**, as known in the art.

The steering shaft assembly **34** also is pivotally connected to a clamping bracket **42** by a pin **44**. This convention coupling permits the outboard motor **10** to be pivoted relative to the pin **44** to permit adjustment of the trim position of the outboard motor **10** and for tilt-up of the outboard motor **10**.

Although not illustrated, it is understood that a conventional hydraulic tilt-and-trim cylinder assembly, as well as a conventional steering cylinder assembly, can be used as well with the present outboard motor **10**. The construction of the steering and trim mechanisms is considered to be conventional, and for that reason, further description is not believed necessary for an appreciation or understanding of the present invention.

The drive shaft **26**, as schematically illustrated in FIG. **1**, continues from the drive shaft housing **28** into the lower unit **30**, where it drives a transmission **46**, which is housed within a nacelle **47**. The transmission **46** selectively establishes a driving condition of a propulsion device **48**, which in the illustrated embodiment is a counter-rotating dual propeller system. A shift mechanism **49** advantageously operates the transmission **46** in forward/neutral/reverse states. In this manner, the propulsion device **48** can drive the watercraft **14** in any of these three operational states.

The level of the water relative to the watercraft **14** desirably lies proximate to the cavitation plate **32** when the watercraft is at rest (i.e., idling), is accelerating from low speeds, or is decelerating, as well as during low speed operation of the watercraft **14**. The propeller system **48** is thus entirely submerged beneath water during low speed operation and acceleration/deceleration of the watercraft **14**.

During high speed operation of the watercraft **14**, the water level desirably lies near the bottom surface **15** of the watercraft **14**. Hence, the watercraft **14** desirably planes along the water surface during high speed operation. Furthermore, only the lower portions of the propeller system **48** contact the water while the watercraft **14** is operating at high speeds. The propeller blades run partially exposed to reduce drag on the outboard motor **10**, as known in the art.

With reference to FIGS. **1** and **2**, the counter-rotating propulsion device **48** includes a front propeller **50** designed to spin in one direction and to assert a forward thrust, and a rear propeller **52** which is designed to spin in an opposite direction and to assert a forward thrust. The propellers **50, 52** thus are of opposite hand and rotate about a common axis. The construction of the propellers will be described below.

An exhaust system discharges engine exhaust from an engine manifold (not shown) of the engine **18**. The engine manifold communicates with an exhaust conduit (not shown) formed within an exhaust guide positioned at the upper end of the drive shaft housing **28**. The exhaust conduit of the exhaust guide (not shown) opens into an expansion chamber **54**. The expansion chamber **54** is formed within the drive shaft housing **28** and communications with a discharge conduit **56** (see FIG. **2**) formed within the lower unit **30**. The discharge conduit **56** terminates at a discharge end **58** formed on the rear side of the lower unit **30**. In this manner, engine exhaust is discharged into the water in which the watercraft **14** is operating and in the vicinity of the propellers **50, 52** to produce a cavitation effect about the front propeller **50** to thereby improve acceleration from low speeds.

As seen in FIG. **2**, an inner propeller shaft **60** drives the rear propeller **52** and a hollow outer propeller shaft drives **62** the front propeller **50**. In the illustrated embodiment, the outer propulsion shaft **62** has a tubular shape. The inner propulsion shaft **60** extends through the outer propulsion shaft **62**. The shafts **60, 62** desirably are coaxial and rotate about a common longitudinal axis.

The inner propeller shaft **60** and the outer propeller shaft **62** extend from the transmission system **46** through a bearing carrier **64**. The bearing carrier **64** rotatably supports the outer propeller shaft **62**, with the inner propeller shaft **60** journalled within the outer propeller shaft **62**. A front needle bearing assembly **66** journals the front end of the outer propeller shaft **62** within the bearing carrier **64**, and a rear needle bearing assembly **68** supports the outer propeller shaft **62** at the rear end of the bearing carrier **64**. A second rear needle bearing assembly **69** supports and journal the inner propeller shaft **60** within and at the rear end of the hollow outer propeller shaft **62**.

A first pair of oil seals **70*a*** are interposed between the bearing carrier **64** and the outer propeller shaft **62** at the rear end of the bearing carrier **64**. Likewise, a second pair of oil seals **70*b*** are interposed between the inner propeller shaft **60** and the outer propeller shaft **62** at the rear end of the outer propeller shaft **62**. The seals **70*a*, 70*b*** inhibit lubricant flow beyond these points.

The rear end of the bearing carrier **64** lies within the opening on the rear side of the lower unit **30** that forms the discharge end **58**. Apertures **64***a* within the structure of the bearing carrier **64** permit exhaust gases to flow over the sides of the bearing carrier **64** and through the discharge end **58**, as schematically illustrated in FIG. **2**.

The inner propeller shaft **60** includes a longitudinal bore **72** that stems from the front end of the inner shaft **60** in an axial direction to a point beyond an axis of the drive shaft **26**. An aperture extends through the inner shaft **60**, transverse to the axis of the longitudinal bore **72**, at a position that is generally beneath the drive shaft **26**.

The outer propulsion shaft **62** also includes an integrally formed thrust flange **74** located forward of the front needle bearing assembly **66**. The thrust flange **74** has a forward facing surface that engages a thrust bearing (not shown) to transfer the forward driving thrust from the propeller **50** through the thrust bearing to the lower unit housing **30**. Because the thrust flange **74** and bearing assemblies which journal the propeller shafts **60**, **62** within the bearing carrier **64** form no significant part of this invention, further description of these elements is not believed necessary for an understanding of the present invention.

The engine **18** drives the propeller shafts **60**, **62** through a drive train formed at least in part by the drive shaft **26** and the transmission **46**. The individual components of the present transmission **46** will now be described in detail with reference to FIG. **2**.

As seen in FIG. **2**, the lower end of the drive shaft **26** is suitably journaled within the lower unit **30** by a bearing assemblies **76**. At its lower end, the drive shaft **26** carries a drive gear or pinion **78** which forms a portion of the transmission **46**. The pinion **78** preferably is a bevel-type gear.

The transmission **46** also includes a pair of counter-rotating driven gears **80**, **82** that are in mesh engagement with the pinion **78**. The pair of driven gears **80**, **82** preferably are positioned on diametrically opposite sides of the pinion **78**, and are suitably journaled within the lower unit **30**, as described below. Each driven gear **80**, **82** is positioned at about a 90° shaft angle with the drive shaft **26**. That is, the propeller shafts **60**, **62** and the drive shaft **26** desirably intersect at about a 90° shaft angle; however, it is contemplated that the drive shaft **26** and the propeller shafts **60**, **62** can intersect at almost any angle.

In the illustrated embodiment, the pair of driven gears **80**, **82** are a front bevel gear **80** and an opposing rear bevel gear **82**. The front bevel gear includes a hub **84** which is journalled within the lower unit **30** by a front thrust bearing **86**. The thrust bearing **86** rotatably supports the front gear **80** in mesh engagement with the pinion **78**.

As seen in FIG. **2**, the hub **84** has a center bore through which the inner propulsion shaft **60** passes. The inner propulsion shaft **60** is suitably journalled within the central bore of the front gear hub **84**.

The front gear **80** also includes a series of teeth on an annular front-facing engagement surface, and includes a series of teeth on an annular rear-facing engagement surface. The teeth on each surface positively engage a portion of a clutch element of the transmission **46**, as described below.

The rear gear **82** also includes a hub **92** which is suitably journaled within the bearing carrier **64** by a rear thrust bearing **96**. The rear thrust bearing **96** rotatably supports the rear gear **82** in mesh engagement with the pinion **78**.

The hub **92** of the rear gear **82** has a central bore through which the inner propeller shaft **60** and the outer propeller shaft **62** pass. The rear gear **82** also includes an annular front engagement surface which carries a series of teeth for positive engagement with a clutch element of the transmission **46**, as described below.

As best seen in FIG. **2**, the inner propulsion shaft **60** extends through the front gear hub **84** and the rear gear hub **92** and is suitable journalled therein. On the rear side of the rear gear **82**, the inner propulsion shaft **60** extends through the outer propulsion shaft **62** and is suitable journalled therein.

As seen in FIG. **2**, the transmission **46** also includes a front clutch **110** and a rear clutch **112** coupled to a plunger **114**. As discussed in detail below, the front clutch **110** selectively couples the inner propulsion shaft **60** to the front gear **80**. The rear clutch **112** selectively couples the outer propulsion shaft **62** either to the front gear **80** or to the rear gear **82**. FIG. **2** illustrates the front clutch **110** and the rear clutch **112** set in a neutral position (i.e., in a position in which the clutches **110**, **112** do not engage either the front gear **80** or the rear gear **82**). In the illustrated embodiment, the clutches **110**, **112** are positive clutches, such as, for example, dog clutch sleeves; however, it is contemplated that the present transmission **46** could be designed with friction-type clutches.

The plunger **114** includes a generally cylindrical rod-shape body and slides within the longitudinal bore **72** of the inner shaft **60** to actuate the clutches **110**, **112**. The plunger **114** desirably is hollow (i.e., is a cylindrical tube).

The plunger **114** includes a front hole that is positioned generally transverse to the longitudinal axis of the plunger **114** and a rear holes that is likewise positioned generally transverse to the longitudinal axis of the plunger **114**. The holes desirably are each located symmetrically in relation to the corresponding apertures of the inner propulsion shaft **60**, with the plunger **114** set in the neutral position.

The transmission **46** also includes a neutral detent mechanism **120** to hold the plunger **114** (and the coupled clutches **110**, **112**) in the neutral position. The neutral detent mechanism **120** operates between the plunger **114** and the inner propulsion shaft **60**, and is located toward the front end of the inner propulsion shaft **60**.

As best seen in FIG. **2**, the neutral detent mechanism **120** is formed in part by at least one and preferably two transversely positioned holes in the plunger **114**. These holes receive detent balls **122**. The detent balls **122** each have a diameter which is slightly smaller than the diameter of each hole.

The inner propulsion shaft **60** includes an annular groove **124** which is formed on the inner wall of the bore **72** through which the plunger **114** slides. The groove **124** is positioned within the bore **72** so as to properly locate the clutches **110**, **112** in the neutral position when the detent holes of the plunger **114** coincide with the axial position of the annular groove **124**. A spring plunger **126**, formed in part by a helical compression spring, biases the detent balls **122** radially outwardly against the inner wall of the inner propulsion shaft bore **104**. The plunger **114** contains the spring plunger **126** within its tubular body.

The spring plunger **126** forces portions of the detent balls **122** into the annular groove **124** when the plunger **114** is moved into the neutral position. This releasable engagement between the detent balls **122** carried by the plunger **114** and the annular groove **124** of the inner propulsion shaft **60** releasably restrains movement of the plunger **114** relative to the inner propulsion shaft **60**, as known in the art. Because the detent mechanism **120** is believed to be conventional, further description of the detent mechanism **120** is thought unnecessary for an understanding of the present transmission **46**.

As seen in FIG. **2**, the front dog clutch **110** has a generally cylindrical shape that includes an axial bore. The bore extends through an annular front end and a flat annular rear end of the clutch **110**. The bore is sized to receive the inner propulsion shaft **60**. Internal splines are formed on the wall of the axial bore. The internal splines mate with external spines formed on the front end of the inner propulsion shaft **60**. The resulting spline connection establishes a driving connection between the front clutch **110** to the inner propulsion shaft **60**, while permits the clutch **110** to slide along the front end of shaft **110**.

The annular rear end surface of the clutch **110** lies generally transverse to the longitudinal axis of the inner propulsion shaft **60**. The rear surface of the front dog clutch **110** also is substantially coextensive in the area with the annular front surface of the front gear **80**. Teeth extend from the clutch rear surface in the longitudinal direction and desirably corresponds with the teeth on the front surface of the front driven gear **80**, both in size (i.e., axial length), in number, and in configuration.

A pair of annular grooves circumscribe the exterior of the front clutch **110**. A front groove is sized to receive a retaining spring, as described below. The rear groove is sized to cooperate with an actuator mechanism, which will be described below.

The front clutch **110** also includes a traverse hole that extends through the clutch **110** at the location of the front annular groove. The hole is sized to receive a pin **138** which, when passed through the front aperture **140** of the inner propulsion shaft **60** and through the front hole of the plunger **114**, interconnects the plunger **114** and the front clutch **110** with the front clutch **110** positioned on the inner propulsion shaft **60**. The pin **138** may be held in place by a press-fit connection between the pin **138** and the front hole, or by a conventional coil spring (not shown) which is contained within the front annular groove about the exterior of the front clutch **110**.

The rear clutch **112** is disposed between the two counter-rotating driven gears **80, 82**. The rear clutch **112** has a tubular shape that includes an axial bore which extends between an annular front end and an annular rear end. The bore **140** is sized to receive a portion of the outer propulsion shaft **62**, which is positioned about the inner propulsion shaft **60**.

The annular end surfaces of the rear clutch **112** are substantially coextensive in size with the annular engagement surfaces of the front and rear gears **80, 82**, respectively. Teeth extend from the front end of the rear clutch **112** and desirably correspond to the respective teeth of the front gear **80** in size (e.g., axial length), in number, and in configuration. Teeth likewise extend from the rear end surface of the rear clutch **112** and desirably correspond to the respective teeth of the rear gear **82** in size (e.g., axial length), in number, and in configuration.

A spline connection couples the rear clutch **112** to the outer propulsion shaft **62**. The clutch **112** thus drives the outer propulsion shaft **62** through the spline connection, yet the clutch **112** can slide along the front end of the shaft **62** between the front and rear gears **80, 82**.

As seen in FIG. **2**, the rear clutch **112** also includes a counterbore. The counterbore is sized to receive a coupling pin **148** which extends through the rear aperture **149** of the inner propulsion shaft **60** and through the rear hole of the plunger **114**. The ends of the pin **148** desirably are captured by an annular bushing which is interposed between a pair of roller bearings. The assembly of the couplings and bearings is captured between a pair of washers and locked within the counterbore of the rear clutch **112** by a retainer ring (not shown). The roller bearings journal the assembly of the bushing and the pin **148** within the counterbore to allow the bushing and the pin **148** to rotate in an opposite direction from the rear clutch **112**. The pin **148**, being captured within the counterbore of the rear clutch **112**, however, couples the plunger **114** to the rear clutch **112** in order for the plunger **114** to actuate the rear clutch **112**.

As seen in FIG. **2**, the actuator mechanism **49** moves the plunger **114** of the clutch assembly from a position establishing a forward drive condition, in which the front and rear clutches **110, 112** engage the front and rear gears **80, 82**, respectively, through a position of non-engagement (i.e., the neutral position), and to a position establishing a reverse drive condition, in which the rear clutch **112** engages the front gear **110**. The actuator mechanism **49** positively reciprocates the plunger **114** between these positions.

The actuator mechanism **49** includes a cam member **176** that connects the front clutch **110** to a rotatable shift rod **178**, which is housed within a sealed vertical chamber within the lower unit **30**. In the illustrated embodiment, the shift rod **178** is journalled for rotation in the lower unit **30** and extends upwardly to the transmission actuator mechanism **49** positioned within the outboard motor cowling **20**. The actuator mechanism **49** (not shown) converts rotational movement of the shift rod **178** into linear movement of the front clutch **110** to move the front clutch **110**, as well as the plunger **114** and the rear clutch **112**, along the axis of the propulsion shaft **60, 62**.

The cam member **176** is affixed to a lower end of the shift rod **178**. The cam member **176** includes an eccentrically positioned drive pin **138** which extends downward from the cam member **176** and cooperates with the rear groove on the front clutch element **110**. The cam member also includes a cylindrical upper portion which is positioned to rotate about the axis of the shift rod **178** and is journaled within the lower unit **30**.

The drive pin **138** of the cam member **176** moves both axially and transversely with rotation of the cam member **176** because of the eccentric position of the drive pin **138** relative to the rotational axis of the cam member **176**. The axial travel of the drive pin **138** causes the coupled clutch **110** to move axially, sliding over the inner propulsion shaft **60**, as discussed in detail below.

As noted above, the pin **138** connects the front clutch **110** to the plunger **114**. This coupling causes the plunger **114** to rotate with the front clutch **110** and the inner propulsion shaft **60**. The coupling also conveys the axial movement of the clutch **110** driven by the actuator mechanism **49** to the plunger **114**. The plunger **114** consequently moves the rear clutch **112** which travels with the plunger **114**.

FIGS. **1** and **2** also illustrates a water pick-up system for the outboard motor **10**. A water inlet **184** is located on each side of the front end of the lower unit **30**. Each water inlet **184** is defined by an opening that extends through the lower unit **30** and is located on an upper side of the front portion of the nacelle, forward of the transmission **46**. A cover **186** is positioned over each water inlet **184**.

Each opening **184** extends through the nacelle **47** and communicates with a water passage **192** that extends upward through the lower unit **30**. The water passage **192** desirably is positioned forward of the transmission **46** and the shift rod **178** and is separated therefrom by an internal wall within the lower unit **30**.

The water passage **192** communicates with a water pump **208**. The water pump **208** is located within the drive shaft housing **28** immediately above the junction where the drive shaft housing **28** meets the lower unit **30**. The water pump **208** is coupled to the drive shaft **26** such that the drive shaft **26** powers the pump **208**.

The water pump **208** communicates with a water tube fitting **210** that is located on a rear side of the water pump **208**. The water tube fitting **210** is defined by a wall **212** that separates the water tube fitting **210** from the discharge conduit **56**. A flexible tube **214** is connected to the water tube fitting **210** and extends upward through the drive shaft housing **28** to communicate with water jackets (not shown) that extend through the engine **18**.

As the watercraft travels through water, the relative velocity between the water and the nacelle **47** urges water through the plurality of openings **184** in the water inlet cover **186**. The momentum of the water as it passes through the inlet propels the water upward through the water passage **192**, thus filling the water passage **192** with water. The pump **208** also helps draw water into the water passage **192**, especially at low speeds. The water pump **208** then pumps the water from the water passage **192** and into the water tube fitting **210** and delivery tube **214**. The water delivery tube **214** guides the water to the engine **18** for cooling. The method by which the water, once within the engine, cools the engine is considered to be conventional. For that reason, further description is not believed to be necessary for an appreciation or understanding of the present invention.

FIG. **3** best illustrates the components of the front and rear propellers **50, 52**. The rear propeller includes a hub **220** to which propeller blades **222** are integrally attached. An inner propulsion shaft **60** drives the rear propeller hub **220**. For this purpose, the rear end of the inner propulsion shaft **60** carries an engagement sleeve **223** of the propeller **52** which has a spline connection with the rear end of the rear propulsion shaft **60**. The sleeve **223** is fixed to the rear end of the inner shaft **60** between a nut **226** threaded on the rear end of the shaft **64** and a rear thrust washer **228** positioned between the front and rear propeller **50, 52**.

An elastic coupling **230** is interposed between the inner engagement sleeve **223** and the rear propeller hub **220**. The coupling **230** is secured to the engagement sleeve **223** by a known heat process, such as, for example, shrink fit process or the like, or by an adhesive bonding. The coupling **230** is attached to the inner surface of the propeller hub **220** also by suitable means, such as, for example, by a known heat process or an adhesive bonding.

The engagement between the hub **220** and the elastic coupling **230** is sufficient to transmit rotational forces from the engagement sleeve **223**, driven by the inner propulsion shaft **60** to the rear propeller blades **222**. The coupling **230** also provides vibration damping between the drive shaft **60** and the propeller hub **220**.

The hub **220** is supported about the inner sleeve **223** by an annular inner flange **232** and a spacer **234**. The inner flange **232** of the hub **220** engages a portion of the thrust washer **228**. The spacer **234** fits behind the inner sleeve **223**, between the inner shaft **60** and the propeller hub **220** with the nut **226** securing the spacer **234** in this location.

The front propeller **50** includes a propeller hub **236**. Propeller blades **238** are integrally formed on the exterior of the hub **236**.

An outer propulsion shaft **62** carries the front propeller **50**. As best seen in FIGS. **3**, and **4** the rear end portion of the outer propulsion shaft **62** carries a front engagement sleeve **240** of the front propeller **50** and drives the engagement sleeve **240** by a spline connection. The front engagement sleeve **240** is secured onto the outer propulsion shaft **62** between an annular retaining ring **242** and a front thrust valve **224**.

A front annular elastic coupling **246** surrounds the front engagement sleeve **240**. The coupling **246** is secured to the sleeve **240** by a variety of suitable ways known in the art, such as, for example, by a heat shrink process or by an adhesive bonding.

The front propeller hub **236** surrounds the elastic coupling **246**, which is secured to an inner surface of the propeller hub **236** by a suitable manner, such as, for example, by a heat shrink process or by an adhesive bonding. The engagement between the propeller hub **236** and the coupling **246** is sufficient to transmit a rotational force from the sleeve **240** to the propeller blades **238** of the front propeller hub **236**. The elastic coupling **246** dampens vibration between the outer propulsion shaft **62** and the front propeller hub **236**.

The elastic coupling **246** desirably is contained within a substantially constant space S that is defined solely between an inner member **248** and the propeller hub **236**. The constant space S inhibits deformation of the elastic coupling **246** which minimizes the degree of cyclic tension and compression stresses placed on the elastic coupling as the propeller **50** rotates. As a result, the elastic material of the coupling **246** is less likely to fatigue and the durability of the coupling **246** is improved.

In the illustrated embodiment, the space S is defined between an annular surface **250** of the inner sleeve **240**, which forms part of the inner member **248**, and an inner periphery surface **254** of the propeller hub **236**. Cooperating structure between the propeller hub **236** and the inner member **248** maintain the spacing between the opposing surface **252, 254** of these components **236, 240**. In the illustrated embodiment, the propeller hub **236** includes a radial extending member which extends inward from the inner periphery **254** of the propeller hub **236** and contacts at least a front end **256** of the inner sleeve **240**. In particular, the radial extending member comprises an annular flange **258** that extends about the inner periphery **254** of the propeller hub **236**. The annular flange **258** contacts the front end **256** of the inner sleeve **240** as well as hub portion **260** of the front thrust flange **224**. This structure substantially prevents relative movement between the inner member **248** and the hub **236** in a direction transverse (i.e., radial) to a rotational axis of the propeller **50** as the propeller rotates.

The inner member **248** also includes a radial extending member that supports the propeller hub **236** about a rear end of the engagement sleeve **240**. In the illustrated embodiment, the radial extending member is an annular flange **262** that circumscribes a rear end of the engagement sleeve **240**. An outer end of the annular flange **262** fits within the inner periphery **254** of the propeller hub **236** in generally a slip-fit manner. As such, the annular flange **262** contacts the inner periphery **254** of the propeller hub **236**. This structure, like the front structure, substantially prevents relative movement between the propeller hub **236** and the inner member **248** in the transverse (i.e., radial) direction as the propeller **50** rotates.

The radial extending member and the inner sleeve desirably are integrally formed. That is, the inner member **248** is a unitary piece. As described in connection with other embodiments, however, the inner member **248** can be formed by separate components that are attached together (e.g., by an adhesive bonding or welding) before assembly.

Importantly the space S in which the elastic coupling **246** is placed is formed solely by the inner member **248** and the propeller hub **236**. As a result, the number of components that form the propeller **50** is reduced in comparison to prior propeller designs to decrease assembly labor and material costs associated with the propeller **50**.

The following elaborates upon the foregoing description of the operation of the transmission **46** and the propeller system **48**. FIG. **2** illustrates the front and rear clutches **110**, **112** in the neutral position, i.e., a position of non-engagement with the gears **80**, **82**. The detent mechanism **120** maintains the plunger **114** and the coupled clutches **110**, **112** in this position.

To establish a forward drive condition, the shift rod **178** rotates the cam member **176** in a manner which moves the drive pin of the cam member **176** axially in the reverse direction. In the illustrated embodiment, clockwise rotation of the shift rod **178** moves the drive pin axially in the rearward direction. The clutch **110** thus follows the drive pin to slide the front clutch **110** over the inner propulsion shaft **64**. The actuator mechanism **49** thereby forces the front clutch **110** into engagement with the front gear **80**, with the corresponding clutch teeth mating. So engaged, the front gear **80** drives the inner propulsion shaft **60** through the internal spline connection between the clutch **110** and the inner propulsion shaft **60**. The inner propulsion shaft **60** thus drives the rear propeller **52** in a first direction which asserts a forward thrust.

The forward motion of the clutch **110** also causes the plunger **114** to slide within the longitudinal bore **72** of the inner propulsion shaft in the reverse direction due to the direct coupling of the drive pin **138**. The plunger **114** moves the rear coupling pin **148** in the rearward direction to force the rear clutch **112** into engagement with the rear gear **82** with the corresponding teeth mating.

Once the teeth of the rear clutch **112** register with the teeth of the rear gear **82**, the rear clutch **112** engages with the rear gear **82**. So engaged, the rear gear **82** drives the outer propulsion shaft **62** through the spline connection between the rear clutch **112** and the outer propulsion shaft **62**. The outer propulsion shaft **62** thus drives the front propeller **50** to spin in an opposite direction to that of the rear propeller **52** and to assert a forward thrust.

To establish a reverse drive condition, the shift rod **178** rotates in an opposite direction so as to move the cam member **176** and the eccentrically positioned drive pin in a direction which moves the drive pin axially in the forward direction. Again, in the illustrated embodiment, clockwise rotation of the shift rod **178** rotates the drive pin **138** so as to move the drive pin axially in the forward direction. The forward movement of the drive pin **138** is transferred to the front clutch **110**. This motion also is transferred to the plunger **114** through the clutch **110** and the corresponding coupling pin **138**. The forward motion of the plunger **114** positively forces the rear clutch **112** into engagement with the front gear **80** with the corresponding clutching teeth mating.

Once the corresponding teeth of the rear clutch **112** and front gear **80** register, the front gear **80** and rear clutch **112** engage. So engaged, the front gear **80** drives the outer propulsion shaft **62** through the spline connection between the rear clutch **112** and the outer propulsion shaft **62**. The outer propulsion shaft **62** thus drives the front propeller **50** in a direction which asserts a reverse thrust to propel the watercraft **14** in reverse.

In the illustrated embodiment, only the front propeller **50** includes the improved construction; however, it is understood that either propeller **50**, **52** or both propellers **50**, **52** can include the improved propeller construction. In addition, it is understood that the front propeller **50**, with the improved construction, can be used with a transmission that drives the front propeller **50** only during forward drive conditions and drives the rear propeller **52** under both forward and reverse drive conditions. Such a transmission is illustrated in U.S. Pat. No. 5,449,306, issued Sep. 12, 1995, to Nakayasu et al., entitled "Shifting Mechanism For Outboard Drive", and assigned to the assignee of this application, which is hereby incorporated by reference.

Several additional embodiments of the propeller system designed to carry out the improvements described above are disclosed below. Each of these embodiments employs the same basic concepts characteristic of improving the durability of the resilient coupling between the propeller hub and the propeller shaft, as well as reducing the number of components of the propeller. For ease of description, similar features are ascribed the same reference numeral used for corresponding elements of the embodiments.

With reference to FIG. **5**, the front propeller **50** includes a similar design to that described above, except for the structure supporting the propeller hub **236** about the outer propeller shaft **62**. In the illustrated embodiment, the inner member **248** includes radial extending members at the ends of the space S. Each radial extending member desirably is an annular flange **262**, **264** that circumscribes the inner engagement sleeve **240**. The annular flanges **262**, **264** are sized to support the propeller hub **236** at a defined distance from the inner sleeve **240** so as to define the generally constant space S between the annular flanges **262**, **264** and the between the inner periphery surface **254** and the surface **250** of inner sleeve **240**. The outer ends of the flanges **262**, **264** contact the inner periphery of the propeller hub **236**, desirably in a slip-fit manner.

The space S thus is formed solely by the inner member **248** and the inner periphery surface **254** of the propeller hub **236**. No other components define the generally constant space S. In addition, this structure substantially inhibits relative radial movement between the inner sleeve **240** and the propeller hub **236**.

The front flange **258** on the propeller hub **236** abuts against the front thrust flange **224**. In this manner, axial thrust from the propeller hub **236** is transferred to the outer propeller shaft **62** through the thrust flange **224**. Substantially no thrust force is transferred through the elastic coupling **246** because of the slip-fit contact between the inner member **248** and propeller hub periphery **254** and the spline connection between the inner member **248** and the propeller shaft **62**.

The construction of the rear propeller **52**, the propeller shafts **60**, **62** the transmission **46**, and the lower unit **30** desirable are identical to the above description.

FIGS. **6** and **7** illustrate another embodiment of a propeller design in connection with the front propeller **50**. This embodiment is substantially identical to the front propeller design illustrated FIG. **3**, except for the construction of the inner member **248** and relationship between the front annular flange **258** of the propeller hub **236** and the contact surface **250** of the inner sleeve **240**. Lie the embodiment of FIG. **5**, the construction of the rear propeller **52**, the propeller shafts **60**, **62** the transmission **46**, and the lower unit **30** desirable are identical to like components of the embodiment described in FIG. **3**.

The inner member **248** comprises an inner engagement sleeve **240** and a radial extending member. The inner sleeve **240** has a tubular shape and includes internal splines that cooperate with external splines formed on the exterior of the outer propeller shaft **62**.

The radial extending member desirably is an annular ring **266** that is attached to the inner sleeve **240** by suitable means, such as, for example, by welding or by an adhesive bonding. The ring **266** is concentrically positioned relative to the inner sleeve **240**. The outer diameter of the ring **266** is sized to be slightly smaller than the diameter of the inner periphery surface **254** of the propeller hub **236** to fit within the propeller hub **236** in a slip-fit manner.

As best seen in FIG. **7**, the front annular flange **258** of the propeller hub **236** contacts a bearing surface **268** on the outer periphery **250** (FIG. **6**) of the engagement sleeve front end **256**. A step **270** is located behind the bearing surface **268** to function as a stop. An inner end **272** of the annular flange **258** contacts and sits flush against the bearing surface **268** to firmly support the propeller hub **236** about the inner sleeve **240**. The annular flange **258** also lies in front of the step **270** with a small space **(280)** occurring between the step **270** and the annular flange **258**. This arrangement allows for a limited degree of relative movement between the propeller hub **236** (FIG. **6**) and the inner member **248** in the axial direction toward the rear propeller **52**. (FIG. **6**)

FIGS. **8** and **9** disclose a very similar propeller design to that illustrated in FIGS. **6** and **7**, with the exception of the contact arrangement between the front annular flange **258** of the propeller hub **236** and the inner sleeve **240**. In this embodiment, the front annular flange **258** contacts a bearing surface **268** on the outer periphery of the engagement sleeve front end **256**. A step **270** is located behind the bearing surface **268**. An inner end **272** of the annular flange **258** contacts and sits flush against the bearing surface **268** to firmly support the propeller hub **236** about the inner sleeve **240**. The annular flange **258** also abuts against the front side of the step **270** to establish a firm and secure contact between the inner sleeve **240** and the inner end **272** of the annular flange **258**. As seen in FIG. **9**, the flange **258** may also include a small chamfer **274** to ensure good contact between the step **272** and a rear side **276** of the annular flange **258**. In this position, the annular flange **258** is locked between the inner sleeve **240** and the front thrust flange **224** to inhibit relative axial movement between these components.

As common to each of the above-described embodiment, at least one of the propellers includes few number of components. In addition, the resilient coupling in the propeller is generally isolated from radial movement of the propeller hub relative to the rotational axis by positioning the coupling within a space having a generally constant size. Each of the above embodiments also include unique advantages associated with the particular propeller design. For this reason, it is understood that those skilled in the art will be readily able to adapt certain features of one embodiments to another in order to suit a particular application.

Although this invention has been described in terms of certain preferred embodiments, other embodiments apparent to those of ordinary skill in the art are also within the scope of this invention. Accordingly, the scope of the invention is intended to be defined only by the claims that follow.

What is claimed is:

1. A propeller adapted to be coupled in driving relation with a propeller shaft of a marine drive, the propeller comprising a propeller hub supporting at least one propeller blade, an inner member adapted to be affixed against rotation relative to the propeller shaft, a space being defined solely by the inner member and the propeller hub with the space occurring between opposing portions of the inner member and propeller hub, a resilient coupler cooperating with the inner member portion and with the opposing propeller hub portion to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub the propeller hub being arranged so as to bear on the propeller shaft in at least one axial direction independent of the coupler.

2. A propeller as in claim **1**, wherein the inner member and the propeller hub include cooperating structure that maintains a constant spacing between the opposing portions of the inner member and the propeller hub.

3. A propeller as in claim **1**, wherein the inner member includes an inner sleeve and at least one radial extending member that projects from the sleeve and supports an inner periphery of the propeller hub about at least a portion of the sleeve.

4. A propeller as in claim **3**, wherein the radial extending member is an annular flange that circumscribes the inner sleeve.

5. A propeller as in claim **4**, wherein the inner member includes another annular flange that circumscribes the inner sleeve, the inner flanges being disposed generally at opposite ends of the inner sleeve.

6. A propeller as in claim **3**, wherein the propeller hub includes at least one radial extending member that projects inward toward the inner sleeve and contacts a portion of the inner sleeve, and the space is defined between the radial extending members of the inner sleeve and the propeller hub.

7. A propeller as in claim **6**, wherein each radial extending member is an annular flange with the annular flange of the inner member circumscribing the inner sleeve and the annular flange of the propeller hub extending about an inner periphery of the propeller hub.

8. A propeller as in claim **7**, wherein the inner sleeve and the annular flange are integrally formed.

9. A propeller as in claim **1**, wherein the propeller hub includes at least one radial extending member that projects inward towards the inner member and is arranged so as to bear on the propeller shaft in at least one axial direction.

10. A propeller as in claim **6**, wherein the inner sleeve includes a relief which receives the radial extending member of the propeller hub in a manner inhibiting axial movement of the propeller hub relative to the inner member in at least one direction.

11. A propeller as in claim **6**, wherein the inner sleeve includes a bearing surface and a stop arranged at one end of the bearing surface, and the radial extending member of the propeller hub contacts the bearing surface in a manner permitting a degree of axial movement of the propeller hub relative to the inner member.

12. A propeller adapted to be coupled in driving relation with a propeller shaft of a marine drive, the propeller comprising a propeller hub supporting at least one propeller blade, an inner member adapted to be affixed against rotation relative to the propeller shaft, a space being defined solely by the inner member and the propeller hub with the space occurring between opposing portions of the inner member and propeller hub, a resilient coupler cooperating with the inner member and with the opposing propeller hub to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub, the inner member including an inner sleeve and at least one radial extending member that projects from the sleeve and supports an inner periphery of the propeller hub about at least a portion of the sleeve, the propeller hub including at least one radial extending member that projects inward toward the inner sleeve and contacts a portion of the inner sleeve, the space being defined between the radial extending members of the inner sleeve and the propeller hub, the inner sleeve including a relief that receives the radial extending member of the propeller hub in a manner inhibiting axial movement of the propeller hub relative to the inner member in at least one direction.

13. A propeller adapted to be coupled in driving relation with a propeller shaft of a marine drive, the propeller comprising a propeller hub supporting at least one propeller blade, an inner member adapted to be affixed against rotation relative to the propeller shaft, a space being defined solely by the inner member and the propeller hub with the space occurring between opposing portions of the inner member and propeller hub, a resilient coupler cooperating with the inner member and with the opposing propeller hub to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub, the inner member including an inner sleeve and at least one radial extending member that projects from the sleeve and supports an inner periphery of the propeller hub about at least a portion of the sleeve, the propeller hub including at least one radial extending member that projects inward toward the inner sleeve and contacts a portion of the inner sleeve, the space being defined between the radial extending members of the inner sleeve and the propeller hub, the inner sleeve including a bearing surface and a stop arranged at one end of the bearing surface, and the radial extending member of the propeller hub contacting the bearing surface in a manner permitting a degree of axial movement of the propeller hub relative to the inner member.

14. A propulsion system for a marine drive comprising a front propeller and a rear propeller arranged in series to rotate about a common axis, a pair of concentric propeller shafts, the front propeller being attached to a first propeller shaft of the pair to drive the front propeller, the rear propeller being attached to a second propeller shaft of the pair to drive the rear propeller, at least one of the front and rear propellers comprising a propeller hub supporting at least one propeller blade, an inner member adapted to be affixed against rotation relative to the respective propeller shaft, a space being defined solely by the inner member and the propeller hub with the space occurring between opposing portions of the inner member and propeller hub, the space having a generally constant size, a resilient coupler cooperating with the inner member portion and with the opposing propeller hub portion to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub, the propeller hub being arranged so as to bear on the propeller shaft in at least one axial direction independedent of the coupler.

15. A propulsion system as in claim **14**, wherein the inner member includes an inner sleeve and at least one annular flange that circumscribes the inner sleeve.

16. A propulsion system as in claim **15**, wherein the inner member includes another annular flange that circumscribes the inner sleeve, the inner flanges being disposed generally at opposite ends of the inner sleeve.

17. A propulsion system as in claim **16** additionally comprising a transmission which drives both propeller shafts and propellers under an forward drive condition and drives only one of the propeller shafts and the respective propeller under a reverse drive condition, and at least the one propeller, which is not driven under the reverse drive condition, includes the inner sleeve with the annular flanges.

18. A propulsion system as in claim **15**, wherein the propeller hub includes at least one radially extending member that extends about an inner periphery of the propeller hub, and the space is defined between the annular flange of the inner member and the radially extending member of the propeller hub.

19. A propeller as in claim **18**, wherein the inner sleeve and the annular flange are integrally formed.

20. A propeller as in claim **18**, wherein the inner sleeve includes a relief which receives the radial extending member of the propeller hub in a manner inhibiting axial movement of the propeller hub relative to the inner member in at least one direction.

21. A propeller as in claim **18**, wherein the inner sleeve includes a bearing surface and a stop arranged at one end of the bearing surface, and the radial extending member of the propeller hub contacts the bearing surface in a manner permitting a degree of axial movement of the propeller hub relative to the inner member.

22. A propulsion system as in claim **18** additionally comprising a transmission which drives both propeller shafts and propellers under an forward drive condition and drives only one of the propeller shafts and the respective propeller under a reverse drive condition, and at least the one propeller, which is not driven under the reverse drive condition, includes the inner sleeve with the annular flanges and the propeller hub with the annular flanges.

23. A propulsion system as in claim **22**, wherein the transmission drives the front and rear propellers in opposite rotational directions under the forward drive condition.

24. A propulsion system as in claim **14**, wherein the propeller hub includes at least one radial extending member that projects inward towards the inner member and is arranged so as to bear on the propeller shaft in at least one axial direction.

25. A propeller adapted to be coupled in driving relation with a propeller shaft of a marine drive, the propeller comprising a propeller hub supporting at least one propeller blade, an inner member adapted to be affixed against rotation relative to the propeller shaft, the propeller hub and the inner member having means for defining a space between opposing portions of the inner member and the propeller hub, a resilient coupler cooperating with the inner member portion and with the opposing hub portion to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub, the propeller hub having means for bearing on the propeller shaft in at least one axial direction independent of the coupling.

26. A propulsion system for a marine drive comprising a front propeller and a rear propeller arranged in series to rotate about a common axis, a pair of concentric propeller shafts, the front propeller being attached to a first propeller shaft of the pair to drive the front propeller, the rear propeller being attached to a second propeller shaft of the pair to drive the rear propeller, at least one of the front and rear propellers comprising a propeller hub supporting at least one propeller blade, the propeller hub and the inner member having means for defining a space of generally constant size between opposing portions of the inner member and the propeller hub, a resilient coupler cooperating with the inner member portion and with the opposing propeller hub portion to resiliently couple together the propeller hub and the inner member, the coupler being disposed within the defined space between the inner member and the propeller hub the propeller hub having means for bearing on the propeller shaft in at least one axial direction independent of the coupling.

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